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**New candidate Pearl millet for the semi-arid agro-ecologies of central Tanzania**

**Proposal for submission to variety release committee**

**ICRISAT ESA Pearl Millet Breeding programme**

**July 2018**



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The support by farming communities of Mlali, Moleti, Laikala and Chitego villages (Kongwa District); Njoro and Kiperesa villages (Kiteto District) and Igula (Iringa District) is acknowledged. Plate 2 shows project stakeholders (Innovation Platform members) meeting in Dodoma.

# **Summary**

Manyara and Dodoma regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. Through Africa RISING Project, ICRISAT and the Department of Agricultural Research Institute (ARI) at Hombolo have been testing new varieties of cereals targeted for these semi-arid agro-ecologies. The studies were conducted between 2013 and 2017 cropping seasons done on farm and on station in the Region. Candidate materials identified from ICRISAT ESA Pearl millet breeding program from the regional adaptability trials were evaluated against the most popular commercial variety *Okoa* and a local land race. On farm testing was done in Moleti and Laikala (Kongwa District) and Igula in Iringa District.

Main traits for this evaluation included; grain yield, days to 50% flowering, agronomic and disease score, 1000g seed mass, number of tillers, number of ears, plant height and farmer preferences. Six genotypes; KAT PM2, SDMV 96063, SDMV 96053, SDMV 94005, IP 8774 and IP 9676 showed great promise both on station (AR—Hombolo) and on farm and may be considered for release. On station and in order of performance; SDMV 94005, SDMV 93063, IP 8774, IP 9676 and KAT PM2 were the best genotypes in terms of grain weight with yield advantages over the local check ranging from 51.9 to 89.3%. For on farm and in order of performance; SDMV 96053, SDMV 94005, IP 8774, IP 9776, SDMV 96063 and KAT PM 2 were consistently the best yielding and most preferred genotypes. All test lines gave better average yields than the local check with yield advantages ranging from 25.4 to 95.7%. These genotypes have shown better resilience compared to all the local checks and if released, are expected to contribute massively to food, income and nutrition security in this Region. Of the seven project sites; Laikala, Moleti and Igula are the driest villages with rainfall below 350mm per annum and targeting these materials to such villages and those with similar climatic conditions in the Region may be very critical to unlocking productivity and alleviating the current food shortage.

Plate 1. Pictures of the six new resilient genotypes submitted for variety release identified from research undertakings in the semi-arid ecologies of Tanzania.

  

  

**Plate 1: Six Pearl millet lines proposed for release**

# **1. Background**

The crop- livestock farming systems in semi-arid agro-ecologies of central Tanzania are in general characterised by low productivity, fragile production-to-market systems, and 3) vulnerability to weather and other natural disaster related challenges. Through Africa RISING, ICRISAT and the Department of Agricultural Research Institutes at Nalendele and Hombolo have been testing new varieties of legumes and cereals targeted for these semi-arid agro-ecologies. These regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. Pearl millet is a major crop, particularly in the central part of Tanzania, comprising Dodoma, Singida, and Shinyanga regions. The crop covers about half of the land under cereal cultivation in the three regions and, apart from sorghum, it is a crop on which farmers depend for their food. The average annual rainfall in these areas is about 600 mm. The farmers have been growing this crop for a long time and the most common varieties are still their local landraces. It is a crop of high value in the community and it is used for food, particularly in the preparation of both thin and stiff porridge, as well as a source of cash. The local landrace varieties take a long time to mature and as a result of the small amount of rainfall in this part of the country, in most years, plants are unable to fill the grain due to early termination of the rains.

In 2013, under the project titled, “*Intensification of Cereal-legume based systems in the semi-arid areas of Tanzania to increase farm productivity and improve the farming natural resource base,*” the team begun to undertake strategic studies to develop new adapted materials for the semi-arid ecologies of central Tanzania. The work was guided by a broader research hypothesis i.e. *participatory deployment of new agricultural innovations; high yielding resilient varieties and appropriate production practices could catalyse and sustain improvements, with wide benefits to the majority of semi-arid populations.* This report contains major results that emanated from the R&D Investments.

# **2. Study Highlights**

All the materials except for the local check were derived from the Pearl Millet Breeding Program for East and Southern Africa centred at ICRISAT-Nairobi. These were materials under Regional evaluation and were selected for their wide adaptation.

## **2.1 The test genotypes**

Genotypes accessed by the project from ICRISAT Nairobi, the centre for cereals (Sorghum and Pearl millet) breeding in the Region were evaluated. Table 1 below only highlights descriptions of six (6) genotypes that had shown great promise both on station and on farm. The genotypes show to be early maturing compared to the two checks. Trait descriptions are based on evaluations made in this research activity.

**Table 1. Description of candidate lines**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | Plant height (cm) | Days to 50% flowering | 1000g seed mass |
| KAT PM2 | 125 | 51 | 18 |
| SDMV 96063 | 132 | 55 | 20 |
| SDMV 96053 | 136 | 52 | 22 |
| SDMV 94005 | 125 | 53 | 17 |
| 1P 8774 | 133 | 56 | 26 |
| IP 9676 | 135 | 55 | 20 |
| Okoa (check) | 143 | 55 | 18 |
| Local landrace (Check) | 180 | 69 | 12 |

## **2.2 Description of study locations**

**The agro-ecology**: Studies were conducted on-station at ARI-Hombolo and on-farm in the districts of Kongwa (Mlali, Moleti, Laikala and Chitego) and Kiteto (Njoro village) in Tanzania (Figure 1). Kongwa district is in Dodoma region which lies at 60 10’S, 35O 45’E and 1120 m above sea level with total annual precipitation averaging 556 mm per year. Kongwa District is a typical semi-arid agro-ecology with temperatures averaging about 28OC and annual precipitation of 400-550 mm[[1]](#footnote-1)). Kiteto district is in Manyara Region, with weather conditions varying from semi-arid to sub-humid. The annual precipitation averages about 682 mm with temperatures of about 19.50C and altitude ranging from 800-2000 m above sea level. The rainfall, however in Kongwa and Kiteto between 2013 and 2016 recorded on farmers’ fields averaged 202.36 mm per year (Appendix 1). A soil-health survey conducted in 2015 in both districts, indicated that soils in the focus villages had very low organic matter (0.17-2%) and other major nutrients, with pH ranging from 4-6 (Appendix 3).



Fig 1 Central Tanzania showing target Districts

**Demand**: A Farmer Research Network[[2]](#footnote-2) approach was used to investigate how cropping systems and socio-economic dynamics in farming communities influence adoption of improved varieties in Central Tanzania. The study was conducted in Kongwa and Kiteto involving 65 households who provided insights on cropping systems and related social dynamics. The study shows that maize, sorghum, pigeon pea, groundnut pearl millet and sunflower are the major crops in the both districts. Yield estimate for pearl + maize intercrops were low with a combined yield of between 370-660 kg/ha. The study also showed that land is mainly owned by men with the exception of Moleti where >65%of women own land.

**Seed systems:** A project study conducted in Kongwa and Kiteto revealed that the Region has a relatively weak to moderate seed system. Only about 10% of farmers use improved or quality declared seed underpinning the fact that farmers lack sufficient options for improved varieties and where to access them (Fig2). Innovation platform meetings (Plate 2) involving all project stakeholders (farmers, agro-dealers, extension and research staff, village, ward and district leaderships) also confirmed lack of improved seeds as one of the major challenges limiting production in the Region.

**Fig 2 seed sources in Kongwa and Kiteto, source: Africa RISING report 2014**

## **2.3 Key results**

Results presented are based on evaluations of twenty-five (25) genotypes which include local checks done on-station as well as on-farmers’ fields between 2013 and 2017. The set of twenty-five was evaluated for two seasons (2013-14 and 2014-15) at ARI Hombolo while 5 lines which were outstanding in the first season (KAT PM2, SDMV 96053, SDMV 94005, IP 8774 and IP 9676) were evaluated on farmers’ fields between 2014 and 2017 with SDMV 96063 as an additional line for on farm testing. For on station, results show SDMV 94005 as the most superior genotype with yield of 1937kg/ha followed by SDMV 93053, IP 8774, IP 9676 and KAT PM 2 giving yields of 1763, 1727, 1555 and 1554kg/ha respectively against a check (Okoa) with yield of 1023kg/ha. The new genotypes had yield advantages over Okoa ranging from 51.9% to 89.3%. The test lines also expressed earliness in maturity with days to 50% flowering of <56 days compared to 69.75 for the local landrace but comparable to Okoa an improved check with 55.5 days to 50% flowering. The genotypes also registered a plant height below 135cm compare to 143.6 and 180.6 cm for Okoa and the local landrace. For on farm, all test lines consistently gave better average yields than the local check with yield advantages ranging from 25.4 to 95.7%. A weak correlation coefficient of 0.1443 between grain weight and number of ears was observed implying that an increase in number of ears did not necessarily result into an increase in the grain weight. In order of performance, overall results put the 7 test line as SDMV 96053, SDMV 94005, IP 8774, IP 9776, SDMV 96063, KAT PM 2 and SDMV 95005 with grain weight ranging from 1179kg/ha to 1840kg/ha compared to 940kg/ha for the local check. The genotype x Village biplot shows Moleti and Igula as better environments than Laikala. Laikala was the driest village of all the villages with an average of 250mm/annum. Results showed IP 8774 as performing better than the rest in Laikala, as such it may be the most drought tolerant genotype which tallies with farmer preference rating where it was selected mainly for drought tolerance

# **3. Detailed Narrative Report**

## **3.1. On station evaluation of genotypes ARI-Hombolo**

ARI-Hombolo is located at 50 75’ S and 350 95’ E with an altitude of 1062 m above sea level receiving an average rainfall of 627mm/annum. Twenty-five (25) genotypes including local checks were evaluated in the 2013-14 and 2014-15 seasons. Main traits for evaluation included; grain weight, days to 50% flowering, 1000g seed mass, number of tillers, plant height, agronomic and disease score. Entries were arranged in Randomized Complete Block Design (RCBD) with two replicates. Materials used were from the Regional Pearl millet variety trials sourced from ICRISAT-Nairobi, the Regional centre for Pearl millet breeding.

### **3.1.1 Performance during the 2013-14 cropping season**

Significant differences, p<0.05 were observed in grain yield, number of tillers, plant height and days to 50% flowering (Table 2). No significant differences were observed for disease and agronomic scores, 1000g seed mass and number of plants lodged. SDMV 94005 was the most superior genotype with yield of 2024kg/ha followed by IP 8774, IP 9776, SDMV 93053 and KAT PM2 with yields ranging from 1198 to 1542kg/ha. Three local checks (Okoa, Tanzania 2 and a local landrace) were used, in this season, however Tanzania 2 and the landrace had yields <600kg/ha as such comparison for yield were made against Okoa only. All the new genotypes had yield advantages over the check ranging from 24.27% to 111%. Even though there were no significant differences for 1000g seed mass, all the test lines gave a higher seed size with weight above 20g compared to 14.5 and 16g for the local land race and Okoa respectively. For plant height, all the new genotypes had an average plant height below 152 cm compared to 205cm for the local check.

**Table 2 Performance during the 2013-14 cropping season**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Grain wt (kg/ha) | Disease score | No of tillers | Agronomic score | Days to 50% flowering | 1000g seed mass | Plant height (cm) |
| ICMV 221 | 908 | 3 | 18 | 2 | 51 | 23 | 133 |
| ICMV 221 WHITE | 1253 | 2 | 22 | 1 | 50 | 24 | 141 |
| ICMV 221-2 | 1011 | 1 | 19.5 | 1.5 | 48.5 | 22.5 | 139.1 |
| ICMV 221-3 | 1068 | 3 | 23.5 | 1.5 | 65 | 20 | 134.6 |
| ICMV 221-4 | 851 | 3 | 18.5 | 2 | 50 | 15 | 128.2 |
| ICMV 221-BRISTLED | 1028 | 2 | 20.5 | 1.5 | 52 | 17 | 143.5 |
| ICMV 91450 | 1123 | 3 | 22.5 | 1.5 | 50 | 19.5 | 140 |
| ICMV 93771 | 952 | 4 | 16.5 | 2 | 48.5 | 35 | 154 |
| ICMV 96603 | 642 | 2 | 21.5 | 2.5 | 56.5 | 20 | 141.6 |
| IP 8765 | 748 | 3 | 20 | 2.5 | 56.5 | 17 | 180 |
| IP 8767 | 618 | 3 | 18.5 | 2.5 | 53.5 | 32 | 152 |
| IP 8774 | 1542 | 3 | 19 | 2 | 58 | 27 | 145.5 |
| IP 9976 | 1534 | 3 | 14.5 | 2.5 | 56.5 | 20 | 142.6 |
| IP 9989 | 1362 | 5 | 20.5 | 1 | 55 | 20 | 161 |
| KAT PM 1 | 1000 | 5 | 13 | 1.5 | 52 | 12 | 128.5 |
| KAT PM 2 | 1198 | 4 | 18.5 | 1.5 | 50 | 24 | 135.5 |
| Local Check | 311 | 5 | 7.5 | 3.5 | 77.5 | 14.5 | 205.7 |
| Okashana 1 | 1501 | 3 | 21 | 1.5 | 48.5 | 19.5 | 145.3 |
| Okashana 2 | 842 | 3 | 17.5 | 2 | 63 | 25.5 | 133.1 |
| Okoa | 964 | 5 | 17 | 1.5 | 53.5 | 16 | 137.5 |
| PMV 3 | 765 | 3 | 16 | 2 | 53.5 | 21 | 139.5 |
| SDMV 90031 | 970 | 3 | 24 | 2 | 55 | 34.5 | 149 |
| SDMV 94005 | 2042 | 3 | 20.5 | 2 | 51.5 | 22.5 | 130.1 |
| SDMV 96053 | 1522 | 2 | 13 | 2 | 52 | 23.5 | 151.6 |
| Tanzania 12 | 598 | 5 | 12.5 | 3 | 72 | 17.5 | 224.7 |
| Mean | **1054** | **3.24** | **18.22** | **1.94** | **55.18** | **21.3** | **148.7** |
| Fpr | <.001 | 0.799 | 0.014 | 0.119 | 0.006 | 0.421 | <.001 |
| sed | 223.6 | 1.833 | 3.461 | 0.6481 | 6.111 | 8.29 | 11.39 |
| CV% | 21.2 | 56.6 | 19 | 33.4 | 11.1 | 38.9 | 7.7 |

### **3.1.2 Performance during the 2014-15 cropping season**

Significant differences, p<0.05 were observed only for grain yield but no significant differences observed for the rest of the traits (Table 3). SDMV 93053 was the most superior genotype with yield of 2004kg/ha followed by IP 8774, KAT PM 2, SDMV 94005 and IP 9676 giving yields of 1912, 1909, 1833 and 1575kg/ha. Similarly, three (3) local checks (Okoa, Tanzania 2 and a local landrace) were used and like the 2013-14 season, Tanzania 2 and the landrace had yields <940kg/ha as such comparison for yield were made against Okoa (1082kg/ha) only. Of the 25 genotypes, only 10 which include the proposed genotypes had yields above 1300kg/ha confirming the superiority of the selected test lines. The new genotypes had yield advantages ranging from 45.5% to 85.2% with 1000g seed mass greater than 18 g compared to 11 for local check. All other test lines including all checks had yields below 1082kg/ha.

**Table 3 Performance during the 2014-15 cropping season.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Grain wt (kg/ha) | No of plant lodged | Days to 50% flowering | Disease score | No of tillers | Agronomic score | 1000g seed mass | Plant height (cm) |
| ICMV 221 | 941 | 13 | 55 | 2 | 19.5 | 2 | 20 | 141 |
| ICMV 221 WHITE | 815 | 12 | 55 | 2 | 16 | 2 | 20 | 122 |
| ICMV 221-2 | 784 | 17 | 50 | 2 | 16 | 2.5 | 17 | 115 |
| ICMV 221-3 | 833 | 4.5 | 51.5 | 2 | 15 | 2.5 | 16.5 | 124.5 |
| ICMV 221-4 | 953 | 7 | 53.5 | 3 | 21.5 | 2 | 17 | 121 |
| ICMV 221-BRISTLED | 1308 | 9.5 | 52 | 2 | 19 | 1.5 | 22.5 | 115.1 |
| ICMV 91450 | 875 | 8 | 64.5 | 1 | 25 | 3 | 10 | 148.9 |
| ICMV 93771 | 975 | 20.5 | 55 | 2 | 21.5 | 2 | 10.5 | 134.5 |
| ICMV 96603 | 960 | 9 | 55 | 2 | 17.5 | 2 | 20 | 123.1 |
| IP 8765 | 864 | 7 | 58 | 3 | 22.5 | 2 | 14.5 | 161.5 |
| IP 8767 | 880 | 8.5 | 52.5 | 3 | 21.5 | 2 | 21 | 148 |
| IP 8774 | 1912 | 5 | 55 | 2 | 15 | 2.5 | 25 | 121 |
| IP 9976 | 1575 | 6.5 | 55 | 2 | 20.5 | 2 | 21 | 128 |
| IP 9989 | 1375 | 3.5 | 63.5 | 4 | 16.5 | 2 | 10 | 193.5 |
| KAT PM 1 | 836 | 11 | 55 | 5 | 21.5 | 2 | 12 | 122.5 |
| KAT PM 2 | 1909 | 19 | 52 | 4 | 17 | 3 | 18 | 114.6 |
| Local Check | 924 | 17.5 | 62 | 2 | 27 | 3 | 11 | 155.9 |
| Okashana 1 | 1505 | 12 | 53.5 | 5 | 21 | 2.5 | 11.5 | 115.5 |
| Okashana 2 | 942 | 12.5 | 56.5 | 5 | 17.5 | 3 | 21.5 | 147 |
| Okoa | 1082 | 15 | 49 | 2 | 17 | 2 | 20.5 | 149.7 |
| PMV 3 | 571 | 9.5 | 56.5 | 2 | 17.5 | 3 | 20 | 125 |
| SDMV 90031 | 1082 | 15 | 49 | 2 | 17 | 2 | 20.5 | 149.7 |
| SDMV 94005 | 1833 | 4 | 55 | 7 | 15 | 3 | 20 | 118 |
| SDMV 96053 | 2004 | 8 | 52 | 3 | 20.5 | 2.5 | 21 | 120.5 |
| Tanzania 12 | 935 | 3 | 65 | 4 | 17 | 2 | 15 | 188.1 |
| Mean | **1147** | **10.3** | **55.24** | **2.92** | **19** | **2.32** | **17.4** | **136.1** |
| Fpr | 0.009 | 0.785 | 0.382 | 0.54 | 0.715 | 0.983 | 0.766 | 0.548 |
| sed | 354.3 | 8.31 | 5.892 | 2.04 | 5.036 | 1 | 7.27 | 31.8 |
| CV% | 30.9 | 80.9 | 10.7 | 69.8 | 26.5 | 43.1 | 41.7 | 23.4 |

### **3.1.3 combined analysis for 2013-14 and 2014-15 cropping seasons**

Significant differences, p<0.05 were observed for grain yield, days to 50% flowering and plant height but no significant differences observed for the rest of the traits (Table 4). Overall, SDMV 94005 was the most superior genotype with yield of 1937kg/ha followed by SDMV 93053, IP 8774, IP 9676 and KAT PM 2, SDMV 94005 and IP 9676 giving yields of 1763, 1727, 1555 and 1554kg/ha respectively against a check (Okoa) with yield of 1023kg/ha. The new genotypes had yield advantages over Okoa ranging from 51.9% to 89.3%. The test lines also expressed earliness in maturity with days to 50% flowering <56 compared to 69.75 for the local landrace but comparable to Okoa an improved check with 55.5 days to 50% flowering. The genotypes also registered a plant height below 135cm compare to 143.6 and 180.6 cm for Okoa and the local landrace. The main disease recorded was leaf blight and results show that its influence was insignificant with scores for all genotypes ranging from 1.5 to 4.5 on a 1-9 scale.

**Table 4 Genotype performance across years**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Grain wt (kg/ha) | No of plant lodged | Days to 50% flowering | Disease score | No of tillers | Agronomic score | Plant height (cm) | 1000g seed mass |
| ICMV 221 | 925 | 12.25 | 53 | 2.5 | 18.75 | 2 | 137 | 21.5 |
| ICMV 221 WHITE | 1034 | 12.5 | 52.5 | 2 | 19 | 1.5 | 131.5 | 22 |
| ICMV 221-2 | 898 | 17 | 49.25 | 1.5 | 17.75 | 2 | 127 | 19.75 |
| ICMV 221-3 | 950 | 6.5 | 58.25 | 2.5 | 19.25 | 2 | 129.6 | 18.25 |
| ICMV 221-4 | 902 | 6.75 | 51.75 | 3 | 20 | 2 | 124.6 | 16 |
| ICMV 221-BRISTLED | 1168 | 13.75 | 52 | 2 | 19.75 | 1.5 | 129.3 | 19.75 |
| ICMV 91450 | 999 | 7.75 | 57.25 | 2 | 23.75 | 2.25 | 144.4 | 14.75 |
| ICMV 93771 | 964 | 13.25 | 51.75 | 3 | 19 | 2 | 144.2 | 22.75 |
| ICMV 96603 | 801 | 13.75 | 55.75 | 2 | 19.5 | 2.25 | 132.3 | 20 |
| IP 8765 | 806 | 5.75 | 57.25 | 3 | 21.25 | 2.25 | 170.8 | 15.75 |
| IP 8767 | 749 | 8.25 | 53 | 3 | 20 | 2.25 | 150 | 26.5 |
| IP 8774 | 1727 | 5.75 | 56.5 | 2.5 | 17 | 2.25 | 133.2 | 26 |
| IP 9976 | 1555 | 7 | 55.75 | 2.5 | 17.5 | 2.25 | 135.3 | 20.5 |
| IP 9989 | 1368 | 3 | 59.25 | 4.5 | 18.5 | 1.5 | 177.2 | 15 |
| KAT PM 1 | 918 | 9.75 | 53.5 | 5 | 18.67 | 1.75 | 125.5 | 15 |
| KAT PM 2 | 1554 | 14 | 51 | 4 | 17.75 | 2.25 | 125 | 18 |
| Local Check | 617 | 2.75 | 69.75 | 3.5 | 17.25 | 3.25 | 180.8 | 12.75 |
| Okashana 1 | 1503 | 11.75 | 51 | 4 | 21 | 2 | 130.4 | 15.5 |
| Okashana 2 | 892 | 12.5 | 59.75 | 4 | 17.5 | 2.5 | 140.1 | 23.5 |
| Okoa | 1023 | 13.5 | 51.25 | 3.5 | 17 | 1.75 | 143.6 | 18.25 |
| PMV 3 | 668 | 8.25 | 55 | 2.5 | 16.75 | 2.5 | 132.2 | 20.5 |
| SDMV 90031 | 1026 | 13.25 | 52 | 2.5 | 20.5 | 2 | 149.3 | 27.5 |
| SDMV 94005 | 1937 | 12.75 | 53.25 | 2.5 | 17.75 | 2.5 | 124 | 16.25 |
| SDMV 96053 | 1763 | 7.25 | 52 | 2.5 | 16.75 | 2.25 | 136.1 | 22.25 |
| Tanzania 12 | 767 | 2.25 | 68.5 | 4.5 | 14.75 | 2.5 | 206.4 | 16.25 |
| Mean | **1101** | **9.65** | **55.21** | **3.08** | **18.67** | **2.13** | **142.4** | **19.37** |
| Fpr | <.001 | 0.075 | <.001 | 0.269 | 0.935 | 0.655 | <.001 | 0.447 |
| sed | 208.7 | 4.622 | 4.342 | 1.286 | 3.463 | 0.5845 | 16.4 | 5.549 |
| CV% | 26.8 | 67.7 | 11.1 | 59 | 26.2 | 38.8 | 16.3 | 40.5 |

### **3.1.4 Genotype x Environment interaction**

Three traits (grain yield, days to 50% flowering and plant height) which showed significant differences in the combined analysis were used to evaluate the genotype x environment interaction. Significant differences, p<0.05 were observed for genotype effects in grain yield, days to 50% flowering and plant height (Table 5). For year (environment) effects, significant differences were observed only for plant height and not for grain yield and days to 50% flowering. No significant differences were observed for the genotype x year (environment) interaction effects for all the three traits. Results on the genotype x year interaction show that performance observed is largely due to genetic differences within genotypes. The genotype x year biplot shows SDMV 96053 as the best genotype in 2013-14 season and SDMV 94005 for the 2014-15 season while IP 8784 ranks second in both season (Fig 3). Results also show IP 8774 as the most stable genotype with 2013-14 as the better season.

**Table 5 Genotype x Environment interaction**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | Grain wt (kg/ha) | Days to 50% flowering | Plant height (cm) |
| ICMV 221 | 925 | 53 | 137 |
| ICMV 221 WHITE | 1034 | 52.5 | 131.5 |
| ICMV 221-2 | 898 | 49.25 | 127 |
| ICMV 221-3 | 950 | 58.25 | 129.6 |
| ICMV 221-4 | 902 | 51.75 | 124.6 |
| ICMV 221-BRISTLED | 1168 | 52 | 129.3 |
| ICMV 91450 | 999 | 57.25 | 144.4 |
| ICMV 93771 | 964 | 51.75 | 144.2 |
| ICMV 96603 | 801 | 55.75 | 132.3 |
| IP 8765 | 806 | 57.25 | 170.8 |
| IP 8767 | 749 | 53 | 150 |
| IP 8774 | 1727 | 56.5 | 133.2 |
| IP 9976 | 1555 | 55.75 | 135.3 |
| IP 9989 | 1368 | 59.25 | 177.2 |
| KAT PM 1 | 918 | 53.5 | 125.5 |
| KAT PM 2 | 1554 | 51 | 125 |
| Local Check | 617 | 69.75 | 180.8 |
| Okashana 1 | 1503 | 51 | 130.4 |
| Okashana 2 | 892 | 59.75 | 140.1 |
| Okoa | 1023 | 55.25 | 143.6 |
| PMV 3 | 668 | 55 | 132.2 |
| SDMV 90031 | 1026 | 52 | 149.3 |
| SDMV 94005 | 1937 | 53.25 | 124 |
| SDMV 96053 | 1763 | 52 | 136.1 |
| Tanzania 12 | 767 | 68.5 | 206.4 |
| Mean | **1101** | **55.21** | **142.4** |
| Fpr genotype | <.001 | <.001 | <.001 |
| Fpr year | 0.123 | 0.96 | 0.012 |
| Fpr gen x year | 0.581 | 0.298 | 0.926 |
| sed | 296.3 | 6.002 | 23.88 |
| CV% | 26.9 | 10.9 | 16.8 |



**Fig 3 genotype x year biplot**

## **3.2. On farm evaluation of genotypes**

### **3.2.1 Farmers’ traits**

Farmers were engaged to evaluate genotypes in a participatory approach in Moleti and Laikala in Kongwa District and Igula in Iringa District (Plate 4). A mother baby approach was used, with at least two mother and four baby sites per village. About 30 farmers hosted a mother site each with 2 baby sites located in a radius of about 5km from the mother sites. Data from baby sites was mostly farmers’ preference of the new genotypes. Field days, regular farmer-researcher meetings were used to collect preference data. Seven genotypes + a local check were evaluated and these included; IP 8774, IP 9676, KAT PM 2, SDMV 93053, SMDV 94005, SDMV 96063 and SDMV 95005. Focus group discussions disaggregated by gender were used to understand what farmers look for in pearl millet varieties. Farmers were also given chance to rank genotypes based on own chosen criterion. Through focus group discussions, each group produced what they considered critical traits for variety evaluation (Table 6). Each farmer selected the genotype of choice based on the stated traits and presented their choices within reasons to the facilitators for tallying (Plate 3). Drought tolerance and panicle size were the most important traits for both women and men. The only difference between the two groups was inclusion of birds’ resistance by women and large seed size by men. The priority given to drought tolerance by both groups shows how critical it is to develop materials that would fit these dry agro-ecologies.

**Table 6 Farmer selection of traits**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Women | | | Men | | |
| Traits | **Scores** | **Rank** | **Traits** | **Scores** | **Rank** |
| Drought tolerance | 220 | 1 | Drought tolerance | 199 | 1 |
| Panicle size | 187 | 2 | Panicle size | 134 | 2 |
| P/disease resistance | 155 | 3 | Early maturing | 122 | 3 |
| No of tillers | 98 | 4 | Seed size | 55 | 4 |
| Birds resistance | 45 | 5 | P/disease resistance | 21 | 5 |

### **3.2.2 Performance during the 2014-15 cropping season**

Seven genotypes were evaluation on farmers’ fields against a local check in Moleti, Laikala and Igula. Main data collected included; Grain yield, number of ears and farmer preferences. Trials were arranged in a Randomized Complete Block Design with two replicates. These villages were selected on the basis of being the driest locations in the three districts. Significant differences, p<0.05 were observed for grain weight but not for number of ears (Table 7). SDMV 93053 was the most superior genotype with yield of 2025kg/ha followed by IP 9976 (1612kg/ha), IP 8774 (1558kg/ha) and SDMV 94005 (1456kg/ha). The test lines had yield advantages >42% over the local check. Results also show that the number of ears may not have had an influence on the grain weight. SDMV 96053 was the most preferred genotype by farmers with a total score of 144.7, selected mainly for its ability to tolerate drought as well as large panicle size. Even though IP 9976 was the second highest yielding genotype (1612kg/ha), it was ranked behind SDMV 94005 (1456kg/ha) which may imply that yield is not the only important trait farmers look for. In this scenario, SDMV 94005 was also selected for its ability to tolerate drought.

**Table 7 performance during the 2014-15 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain wt (kg/ha) | No of ears | Yield advantage | Overall scores | Farmer selection | Reason |
| IP 8774 | 1558 | 151.5 | 103.6 | 117.5 | 4 | Drought, panicle size |
| SDMV 96063 | 1367 | 184.5 | 78.6 | 103.5 | 5 | Drought |
| IP 9976 | 1612 | 341 | 110 | 123.5 | 3 | Panicle size |
| KAT PM2 | 1092 | 189 | 42.7 | 99.2 | 6 | Earliness |
| local | 765 | 156 | 0 | 27.3 | 8 | drought |
| SDMV 94005 | 1456 | 154 | 90.3 | 133.3 | 2 | Panicle size, drought |
| SDMV 95005 | 1179 | 206.5 | 54.1 | 55.1 | 7 | earliness |
| SDMV 96053 | 2025 | 215 | 164.7 | 144.7 | 1 | Drought, panicle size |
| Mean | **1338.7** | **206** |  |  |  |  |
| Fpr | 0.049 | 0.352 |  |  |  |  |
| sed | 354.11 | 78.1 |  |  |  |  |
| CV% | 26.5 | 37.9 |  |  |  |  |

### **3.2.3 Performance during the 2015-16 cropping season**

Significant differences, p<0.05 were observed for grain weight but no differences for number of ears (Table 8). The best three genotypes were SDMV 96063, SDMV 96053 and IP 8774 all with yield > 1800kg/ha and yield advantages over the local check above 40%. All test lines had grain weight above 1400kg/ha compared to 1275kg/ha for the local check. SDMVs 96053 and 96063 were the most preferred genotypes by farmers ranked first and second respectively followed by IP 9976, SDMV 94005, IP 8774 and KAT PM 2 in order of preference. Panicle size, drought tolerance and earliness were the three main reasons for selecting the genotypes. Results also show that all test lines were better than the local check in terms of panicle sizes. The local check though with the lowest score (101.13), was regarded as drought tolerant especially with the stay green trait, that in other instances was an indicator of long duration.

**Table 8 Performance during the 2015-16 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain wt (kg/ha) | No of ears | Yield advantage | Overall scores | Farmer selection | Reason |
| IP 8774 | 1810 | 164 | 41.9 | 199.54 | 5 | Panicle size, drought |
| SDMV 96063 | 1925 | 144 | 50.9 | 183.56 | 2 | Panicle size, earliness |
| IP 9976 | 1633 | 175 | 28 | 233.72 | 3 | Panicle size, drought |
| KAT PM2 | 1569 | 188 | 23 | 104.78 | 6 | Panicle size, drought |
| local | 1275 | 180 | 0 | 101.13 | 8 | drought |
| SDMV 94005 | 1588 | 195.5 | 24.5 | 201.92 | 4 | Panicle size, earliness |
| SDMV 95005 | 1450 | 170 | 13.7 | 122.35 | 7 | Panicle size |
| SDMV 96053 | 1902 | 175.5 | 49.1 | 244.55 | 1 | Panicle size, drought |
| Mean | **1600.3** | **174.6** |  |  |  |  |
| Fpr | 0.018 | 0.646 |  |  |  |  |
| sed | 388.86 | 27.97 |  |  |  |  |
| CV% | 24.3 | 16 |  |  |  |  |

### **3.2.4 Performance during the 2016-17 cropping season**

In this season, no significant difference, p<0.05 were observed for both grain weight and number of ears (Table 9). The yield in this season was the lowest compared to the other two seasons giving an overall mean of 1138.3kg/ha compared to 1338.7kg/ha and 1600.3kg/ha for 2014-15 and 2015-16 seasons respectively (Fig 6). The poor yield could be attributed to low rainfall and poor rainfall distributed in this season (App 1). The season had a shortage especially in the critical months of March and April with planting done in Mid-January. Results however, still show all the new genotypes yielding better than the local check with yield advantage ranging from 18.1 to 97.5%. SDMV 96053 and SDMV 94005 were the best yielding genotypes giving 1592kg/ha and 1448kg/ha respectively. These genotypes were also the most preferred by farmers for their panicle size and earliness. IP 8774, was preferred for its ability to tolerate drought. SDMV 95005 which did not perform well in 2014-15 and 2015-16 seasons, was the second highest yielding genotype in the 2016-17 but still lagged behind SDMVs 96053, 94005 and IP 8774 in farmer preferences.

**Table 9 Performance during the 2016-17 cropping season**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | grain wt (kg/ha) | No of ears | Yield advantage | Overall scores | Farmer selection | Main reason (s) |
| IP 8774 | 1104 | 151.5 | 36.9 | 95.43 | 3 | Drought |
| SDMV 96063 | 978 | 184.5 | 21.3 | 55.34 | 5 | Earliness |
| IP 9976 | 1052 | 246.5 | 30.5 | 55.94 | 6 | Drought |
| KAT PM2 | 952 | 179.5 | 18.1 | 50.33 | 7 | Earliness |
| local | 806 | 142.5 | 0 | 17.23 | 8 | Drought |
| SDMV 94005 | 1448 | 310.5 | 76.6 | 99.45 | 2 | Panicle size, earliness |
| SDMV 95005 | 1340 | 217 | 66.2 | 75.41 | 4 | Drought |
| SDMV 96053 | 1592 | 215 | 97.5 | 104.55 | 1 | Panicle size, earliness |
| Mean | **1138.3** | **204** |  |  |  |  |
| Fpr | 0.496 | 0.539 |  |  |  |  |
| sed | 392.39 | 87.4 |  |  |  |  |
| CV% | 34.5 | 42.8 |  |  |  |  |



**Fig 6 Box plot showing yield variation across years**

### **3.2.5 Combined analysis for 2014-15, 2015-16 and 2016-17 cropping seasons**

Overall results show significant differences, p<0.05 for grain weight but no significant differences for number of ears (Table 10). All test lines giving better average yields than the local check with yield advantages ranging from 25.4 to 95.7%. A weak correlation coefficient (0.1443) between grain weight and number of ears was also observed implying that an increase in number of ears did not necessarily result into an increase in the grain weight. In order of performance, overall results put the 7 test line as SDMV 96053, SDMV 94005, IP 8774, IP 9776, SDMV 96063, KAT PM 2 and SDMV 95005. The genotype x Village biplot shows Moleti and Igula as better environments than Laikala (Fig 7). Laikala is the driest village of all the villages with rainfall averaging about 330mm/annum. Results also show IP 8774 as the genotype that performed well in Laikala, as such it may be the most drought tolerant genotype which tallies with farmer preferences rating where it was selected mainly for drought tolerance.

**Table 10 Combined analysis for 2014-14 and 2014-15 cropping seasons**

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | grain wt (kg/ha) | No of ears | Yield advantage |
| IP 8774 | 1491 | 155.7 | 90.5 |
| SDMV 96063 | 1423 | 171 | 51.4 |
| IP 9976 | 1433 | 254.2 | 52.4 |
| KAT PM2 | 1204 | 185.5 | 28 |
| local | 940 | 159.5 | 0 |
| SDMV 94005 | 1518 | 253 | 61.5 |
| SDMV 95005 | 1179 | 206.5 | 25.4 |
| SDMV 96053 | 1840 | 201.8 | 95.7 |
| Mean | **1347.8** | **195** |  |
| Fpr | 0.002 | 0.114 |  |
| sed | 330.39 | 54 |  |
| CV% | 30 | 33.9 |  |



**Fig 7 Genotype x Environment (Village) biplot**

# **4.0 Conclusions**

Following two seasons of testing at ARI-Hombolo (2013-14 and 2014-15) and three seasons (2014-15, 2015-16 and 2016-17) on farmers’ fields, six genotypes showed great promise in terms of yield and other major traits and these include; SDMV 96053, SDMV 94005, IP 8774, IP 9776, SDMV 96063 and KAT PM 2. These genotypes yielded up to 2000kg/ha with yield advantages over the local checks ranging from 25-95%. Moleti, Laikala and Igula were the main test sites selected based on proneness to drought and or erratic rainfall distribution however, the performance showed by new genotypes compared to the local check provides opportunity for unlocking productivity in this Region. It has also been shown that the local check has a plant height of up 200cm a trait that women farmers indicated adds a lot of drudgery during harvesting. The local check has demonstrated to be a catalyst of continued food shortage as it is log duration with days to 50% flowering of up to 79. The genotype x environment testing shows that the six proposed materials, fit these stressed environments well and if released and made accessible to communities in central Tanzania would greatly help improve the food, nutrition and income security of these vulnerable dry agro-ecologies.

# **5.0 Appendices**

**Appendix 1: Four-year rainfall data for Kongwa and Kiteto**

 

**Plate 2 Innovation Platform members meeting in Dodoma Plate 3: A researcher recording each farmer’s preference** 

**Plate 4: Farmer evaluation of pearl millet lines**

**Appendix 2 Members of the Research Team**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Sex | Institution | Telephone | Role in R&D activities |
| Patrick Okori | M | ICRISAT | +265996777683 | Principal investigator. Design and oversight of the project activities |
| Wills Munthali | M | ICRISAT | +265999420251 | Research associate-breeding. Managing; Trial set up (on farm and on station experimentation), Community seed banks and FRNs. |
| Peter Ngowi | M | ICRISAT | +255713302618 | Research Associate: Co-coordinating Project activities |
| Elirehema Swai | M | ARI Hombolo | +255754542340 | Scientist for soil and water management. He is our link to farmers who are part of the FRN (Host Institute) |
| District Councils |  | Kongwa, Kiteto and Iringa |  | Host Districts, providing lead on policy, Innovation platform members |

**Appendix 3. Results of soil sample analysis for Kongwa and Kiteto**

|  |
| --- |
| **Reference Methods:** pH (CaCl2-1:2.5),Walkley-Black method, Acetate, DTPA extraction, hydrometer method for texture |
| Source: Moleti, Mlali, Laikala, |

**RESULTS:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lab No.** | **Farmer** | **Trial** | **Sample No.** | **Depth (cm)** | **Coordinates** | **Elevation** | **pH (CaCl2)** | **OC (%)** | **OM (%)** | **EN (%)** | **P**  **ppm** | **K**  **Meq. %** | **Ca**  **Meq. %** | **Mg**  **Meq. %** | **Texture**  **Class** |
| **40410** | Janet Maleng’a | Baby | 1 | 2 | S=0610979  E=03648285 | 1267 | 5.19 | **0.17** | **0.34** | **0.02** | 36.11 | **0.53** | **2.52** | **0.94** | LS |
| **40411** | Winie Saigodi | Baby | 2 | 2 | S=0610210  E=03648233 | 1266 | 4.85 | **0.14** | **0.28** | **0.01** | 17.15 | **0.48** | **2.10** | **0.64** | LS |
| **40412** | Faith Mahingusa | Baby | 3 | 2 | S=0610988  E03648147 | 1262 | 5.26 | **0.31** | **0.62** | **0.03** | 7.13 | **0.68** | **3.26** | **1.21** | SL |
| **40413** | Msafira | Baby | 4 | 2 | S=0611564  E=03648873 | 1287 | 5.69 | **0.34** | **0.68** | **0.03** | 17.07 | **0.84** | **4.14** | **1.59** | SL |
| **40414** | Moleni Mafuso | Baby | 5 | 2 | S=0610324  E=03648980 | 1282 | 5.91 | **0.11** | **0.23** | **0.01** | 28.83 | **0.77** | **2.78** | **0.71** | LS |
| **40415** | Prisca self | Mother | 6 | 2 | S=0608928  E=03648167 | 1280 | 5.88 | **0.45** | **0.91** | **0.05** | 29.81 | **1.37** | **5.64** | **1.96** | SCL |
| **40416** | Michael Chityange | Baby | 7 | 2 | S=0609329  E=03648362 | 1272 | 5.92 | **0.98** | **1.99** | **0.10** | 7.74 | **2.59** | **9.16** | **2.08** | SL |
| **40417** | Mariam Lebwanya | Baby | 8 | 2 | S=0611951  E=03636330 | 1159 | 5.30 | **0.42** | **0.85** | **0.04** | 21.24 | **0.89** | **3.42** | **1.23** | SCL |
| **40418** | Samuel Mjoeni | Baby | 9 | 2 | S=0611026  E=03636919 | 1192 | 5.40 | **0.31** | **0.62** | **0.03** | 13.28 | **0.74** | **2.78** | **1.14** | SL |
| **40419** | Mwajob Self | Baby | 10 | 2 | S=0611656  E=.3635622 | 1150 | 5.47 | **0.45** | **0.91** | **0.05** | 11.68 | **1.15** | **3.42** | **1.44** | SL |
| **40420** | Ester Malole | Baby | 11 | 2 | S=0613009  E=03637696 | 1200 | 5.23 | **0.67** | **1.36** | **0.07** | 4.70 | **1.11** | **3.28** | **1.43** | SL |
| **40421** | Sekwawo Mulusu | Baby | 12 | 2 | S=0612339  E=03637437 | 1200 | 5.36 | **0.36** | **0.74** | **0.04** | 5.61 | **0.66** | **3.08** | **1.27** | SCL |
| **40422** | Eda Masegele | Baby | 13 | 2 | S=0611490  E=03637209 | 1187 | 5.13 | **0.48** | **0.97** | **0.05** | 6.22 | **0.87** | **3.32** | **1.22** | SCL |
| **40423** | Laikala | Mother | 14 | 2 | S=0611522  E=03636985 | 1196 | 5.15 | **0.45** | **0.91** | **0.05** | 7.97 | **1.28** | **4.10** | **1.55** | SCL |
| **40424** | Janet Malangula | Baby | 15 | 10 | S=0610979  E=03648285 | 1267 | 4.37 | **0.08** | **0.17** | **0.01** | 29.81 | **0.47** | **1.68** | **0.43** | LS |
| **40425** | Winnie Saigodi | Baby | 16 | 10 | S=0610210  E=03648233 | 1266 | 4.68 | **0.08** | **0.17** | **0.01** | 16.08 | **0.45** | **2.46** | **0.64** | LS |
| **40426** | Faith Malungula | Baby | 17 | 10 | S=0610988  03648147 | 1262 | 5.28 | **0.31** | **0.62** | **0.03** | 15.10 | **0.85** | **3.22** | **1.17** | LS |
| **40427** | Msafira Malang’a | Baby | 18 | 10 | S=0611564  E=03648873 | 1287 | 5.95 | **0.28** | **0.57** | **0.03** | 32.92 | **0.65** | **2.64** | **1.01** | LS |
| **40428** | Moleni Mafuso | Baby | 19 | 10 | S=0610324  E=03648980 | 1282 | 5.64 | **0.17** | **0.34** | **0.02** | 22.23 | **0.58** | **2.32** | **0.71** | LS |
| **40429** | Prisca Self | Mother | 20 | 10 | S=0608928  E=03648167 | 1280 | 5.89 | **0.56** | **1.14** | **0.06** | 11.76 | **1.48** | **3.36** | **2.30** | SCL |
| **40430** | Michael Chityaunge | Baby | 21 | 10 | S=0609329  E=03648362 | 1272 | 6.01 | **0.81** | **1.65** | **0.08** | 11.30 | **2.63** | **8.96** | **2.09** | SL |
| **40431** | Miriam Lebwanya | Baby | 22 | 10 | S=0611951  E=03636330 | 1159 | 4.97 | **0.50** | **1.02** | **0.05** | 7.74 | **1.23** | **4.40** | **1.68** | SC |
| **40432** | Samuel Mjoeni | Baby | 23 | 10 | S=0611026  E=03636919 | 1192 | 5.22 | **0.36** | **0.74** | **0.04** | 8.12 | **0.72** | **3.52** | **1.16** | SL |
| **40433** | Mwajob Self | Baby | 24 | 10 | S=0611656  E=03635622 | 1150 | 5.29 | **0.42** | **0.85** | **0.04** | 5.99 | **0.99** | **2.90** | **1.56** | SL |
| **40434** | Ester malole | Baby | 25 | 10 | S=0613009  E=03637696 | 1200 | 5.24 | **0.45** | **0.91** | **0.05** | 8.88 | **1.09** | **2.74** | **1.44** | SL |
| **40435** | Sekwawo Mulusu | Baby | 26 | 10 | S=0612339  E=03637437 | 1204 | 5.39 | **0.34** | **0.68** | **0.03** | 9.48 | **0.72** | **2.92** | **1.22** | SCL |
| **40436** | Eda Masegele | Baby | 27 | 10 | S=0611490  E=03637209 | 1187 | 5.02 | **0.45** | **0.91** | **0.05** | 9.41 | **0.88** | **3.88** | **1.16** | SL |
| **40437** | Lai Kala | Mother | 28 | 10 | S=0611522  E=03636988 | 1196 | 5.19 | **0.48** | **0.97** | **0.05** | 11.23 | **1.27** | **4.14** | **1.62** | SL |

1. See <https://www.climatedata.eu/climate.php?loc=tzzz0019&lang=en>. [↑](#footnote-ref-1)
2. See [www.Mcknight.org](http://www.Mcknight.org) for details [↑](#footnote-ref-2)